TRADE Program

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Introduction

- Triga Reactor Accelerator Driven Experiment
- Currently, European reactor physics teams are focussed on MUSE at Cadarache
- MUSE -> TRADE sequence
  - the same teams will move to TRADE ca. 2004-2005
- Status of TRADE -> experiments are commencing in September

Objectives of MUSE Program

- Measurement of sub-criticality, and development of techniques for “on-line” monitoring (PNS, correlation techniques, source multiplication)
- Reaction rates of minor actinides
- General core characterization (β/Λ, spectrum, source importance)

MUSE

- MUSE 1 and 2 Cf source driven
- MUSE 3 commercial 14Mev generator
  - many problems!
- MUSE 4 GENEPI (from CNRS)
  - DT and DD
  - 3 x 10^6 n/pulse
  - 50-5000 Hz (reactor break frequency about 1500 Hz)

MUSE 4 Program

- MUSE 4 first went critical in January 2001
- GENEPI with deep subcritical June 2001
- GENEPI near critical November 2001
- Reference core measurements through September 2002 (characterization at critical)
- Fall 2002-Fall 2003
  - k=0.995, 0.97, 0.95
  - DD and DT

MUSE Program (2)

- At present, we are preparing for last level of reactivity (k=0.95)
- A short program with lead coolant (vs sodium) is planned for early 2004
- MASURCA will then be embarking on a FGR critical program

MUSE Program (3)

- Data available for
  - critical reference configuration (profiles)
  - k=0.995, DD and DT
  - k=0.97, DD and DT
  - k=0.95 DT
- PNS, source jerk, CPSD, Rossi- and Feynman- α as well as fission and californium traverses

MUSE Program (4)

- This would have been an ideal program to involve US universities, students and faculty
- Opportunity to train young researchers in the lost arts of experimental techniques
- Too late now for MUSE---but TRADE is coming!

TRADE Background

- ENEA (Italy) and Carlos Rubbia
- Couple an existing TRIGA reactor with a spallation source
- Originally to be115 Mev cyclotron/tungsten target, then 140 Mev
- Now maybe 300 Mev (!)/tantalum target
- TRIGA has temperature feedback >1Kw
- Sequence of validation to a real ADS

MUSE and TRADE---Progressive Steps

- MUSE can
  - Investigate source importance effects to 14 MeV
  - Investigate aspects of flux distributions in a fast spectrum
  - Validate dynamic methods of zero-power reactivity measuring and monitoring (a major objective)

MUSE and TRADE---(2)

- MUSE cannot
  - Investigate source importance above 14 MeV
  - Investigate power/current/importance relations
  - Study dynamic effects with power feedback
  - Study operational procedures (startup/shutdown, reactivity swings)

MUSE and TRADE---(3)

- TRADE can
  - Study dynamic effects at power at different subcriticality levels (feedback vs. source effects)
  - Study startup/shutdown scenarios
  - Study current vs control rods for reactivity compensation
  - Validation of beam control/shutdown approach

MUSE and TRADE---(4)

- TRADE can
  - In general, study all relevant aspects of current/power/importance/control rod relations
  - Be used to test dynamic methods developed in MUSE in a thermal system (“generic validation”)
  - Study the effects of different buffers

MUSE vs TRADE

- A multi-step process to validate methods
  - MUSE provides the validation of reactivity measurements at zero power
  - TRADE provides the bridge to more protypical source and feedback effects, full scale validation of ADS concept in terms of coupling of realistic components
  - Spectrum is not an issue with these objectives (simply shift in break freq)

Sequence of Validation

CONFIG	**SOURCE**	**KINETICS**	**FDB**
MUSE	DD/DT	FAST	NO
TRADE	DD/DT	THERMAL	NO
TRADE	SPALL	THERMAL	NO
TRADE	SPALL	THERMAL	YES
ADS	SPALL	FAST	YES

TRADE Working Group

- Initiated in early 2001 with meetings in Rome
- Purpose was to generate a feasibility report
- Initial members from ENEA, CEA, CERN, and Ansaldo (Italian manufacturing company)
- Final feasibility report was presented in Rome in June, 2002
- Formal invitations extended to DOE and FZK
- www.enea.it for more information on report (click Attivita)

TRADE Working Group (2)

- 2 large progress reports since FFR
  - July, 2002
  - April, 2003
- Extensive web site for partners (private) with all technical reports and data obtained to date

TRADE Working Group (3)

- Informal project organization based on working group
  - General ENEA
  - Physics ENEA
  - In-pile experiments ANL
  - Thermal hydraulics CEA
  - Accelerator and BTL ENEA

TRADE Working Group (4)

- Informal project organization (2)
  - Target system ENEA
  - Safety FZK and ENEA
  - Engineering ANSALDO and ENEA
- Finalization and formalization of the project is desired by end of 2003

FTE (order of magnitude)

- ANL 1
- LANL ?
- CEA 5
- ENEA 10
- FZK 2
- Others (e.g., CERN) 1

Main Efforts

- Choice of target
  - tungsten or tantalum or combination
- Thermal hydraulics and safety case
  - although natural convection is probably feasible for less than 20 Kw on target, not enough data are available, so likely will use forced convection on target
  - validation experiments

Main Efforts (2)

- Physics
  - benchmark (ANL, CEA, ENEA, FZK)
  - shielding
  - burn-up evaluation
  - not much experience with U-ZrH fuel
- Accelerator feasibility

TRADE Experiments

- Pre-TRADE characterizations Fall 2002 to Summer 2003
- TRADE Reference Core Fall 2003
- TRADE SC with DT source Summer 2004
- TRADE SC with cyclotron Summer 2006 (7?)

Pre-TRADE core characterizations

- TRADE configuration will require removal of all A and B ring fuel (6 elements actually)
- In Fall, 2002 we performed some initial tests
  - of detectors
  - of reactivity levels with fuel removal
- We found we needed new detectors, and reactivity might be a problem with old fuel

Burn-up evaluations

- Some fuel has been in reactor for 30 years
- We have a good record of fuel locations and power history
- An effort was made in summer to evaluate burn-up experimentally (gamma scanning and reactivity worth)
- This will be fed into the benchmark effort
- Very sensitive to flux gradients

2003-2004 Experiments

- Reactivity transients for the safety group
- Transition to TRADE mockup core
  - removal of A and B rings
  - movement of control rods to D ring
  - removal of all other experimental loops
  - installation of mockup target

2003-2004 (2)

- Measures with Am-Be and Cf sources
  – source importance, source jerk, MSM
- Noise techniques (measures of β/Λ)
- Feynman- and Rossi-α also
- Will then repeat measures with DD and DT sources (direct comparison to MUSE)
- Campaign is full through 2004

TRADE Conclusions

- Experiments will be conducted jointly by ENEA, CEA (and hopefully DOE)
- The project seems to have enough momentum to survive---ENEA is footing the majority of the capital, and other partners are providing manpower or expertise plus some cash
- Another excellent opportunity for US university involvement